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| --- | --- | --- | --- | --- | --- | --- |
| **Term** | **Class No.** | **Section** | **Units** | **Days & Times** | **Room** | **Mode** |
| Spring 2022 | EE 414 | 001 | 3 | Tue/Thu 8:00-9:15AM | LRC 106C | In-person |

**Enrollment Requirements**

Prerequisite: EE 310 with grade of C or better

**Course Website**

Microsoft Teams course (information in first class)

**Instructor**

Paul G. Flikkema

Email: [paul.flikkema@nau.edu](mailto:paul.flikkema@nau.edu) Please include “EE 414” in the subject line.

Office Hours: Normally these will be virtual. Mondays and Fridays 10-11AM; Wednesdays 11AM-noon. During these times, please email me for a time we can meet via Teams or zoom. I may also be available at other times by appointment–again, please email me.

**Course Description**

Processor architecture taxonomies and building blocks. Examples of system architectures, instruction sets, processors, I/O, memories, computer busses, and peripheral devices. Applications to microcontrollers used in embedded and real-time systems, including discussion of power management and cybersecurity. Fundamental laws limiting processor design. Co-convened with EE 514. Letter grade only.

**Course Purpose**

This course gives you the opportunity to gain a new level of understanding of the design of computers.

Major course themes include (1) performance as a function of pipelining and caching, (2) accelerators and parallel processing, and (3) an understanding of processors in the context of embedded computing, where the “non-functional” aspects of computation—time, energy, and area—form the foundation of both processor and system design.

**Course Student Learning Outcomes**

At the completion of this course, you will understand:

* the definition of computer architecture and organization
* time, energy, area, and security in computation
* the major components of modern computer architecture
* datapaths and pipelining
* memory hierarchy and caching
* performance: functional and non-functional
* application: microcontrollers in embedded and real-time systems
* architectures for acceleration: GPUs, architectures for deep learning
* strategies and solutions for security in processor design

**Assignments / Assessments of Course Student Learning Outcomes**

Learning outcomes are assessed primarily through instructor evaluation of assignments.

**Grading System**

A weighted sum of assessment components is used to determine your final grade in the course:

* Participation in class discussion and activities: **15%**
* Homework assignments: **35%**
* Midterm Exams (two 35-minute mini-exams): **20%**
* Distillation Term Paper: **30%**

Note that all homework assignments are on-line exercises in the zybooks.com on-line text (see below). These have firm deadlines that cannot be changed, so plan your time accordingly.

Grades for the midterm exams and the Distillation Term Paper will be based not only on technical content but also on presenting your work in a well-organized, neat, clear, and professional manner using standard technical terms and symbols, and proper grammar, sentence structure, and punctuation. I will give you detailed guidance on the Distillation Term Paper later in the semester.

Grades will be assigned using the weighted sum described above using this scale:

**A** ≥ 90%, **B** ≥ 80%, **C** ≥ 70%, **D** ≥ 60%, **F** < 60%.

At the instructor’s discretion, grading thresholds may be lowered slightly. Mistakes in grading can happen, and you are encouraged to contact the instructor if there are any mistakes.

**Readings and Materials**

You are **required** to purchase one on-line textbook:

*Computer Organization and Design (1e) – Interactive Version (ARM)* at zybooks.com

To gain access:

1. Sign in or create an account at learn.zybooks.com

2. Enter zyBook code: NAUEE414514FlikkemaSpring2022

3. Subscribe

A subscription is $72. Students may begin subscribing on Dec 27, 2021 and the cutoff to subscribe is Apr 22, 2022. Subscriptions will last until May 21, 2022.

You may also wish to purchase the printed version:

D. A. Patterson and J. L. Hennessy. *Computer Organization and Design: The Hardware Software Interface (ARM Edition)*. 1st edition, Morgan Kaufmann, 2016.

Other recommended resources are:

Arm Cortex-M4 Processor Technical Reference Manual. Available at <https://developer.arm.com/documentation/100166/0001/> online or in pdf format.

J. Yiu. *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors*, 3rd ed., Newnes, 2014. ISBN-13: 978-0124080829

Other references will be provided during the course.

**Course Structure/Approach**

Make a **commitment** to *actively participate* in class. This means:

* Do not eat during class (drinks are OK if not obtrusive).
* To avoid distractions, give class your full attention; shut down email, social media, and non-class browser windows, and silence your phone.
* Make a further **commitment** to be *actively involved*: ask and answer questions.
* *Arrive for class a few minutes ahead of time* and get settled so we can start promptly

To give you an incentive to actively participate in class, note that the instructor’s evaluation of your class participation is 15% of your grade. Remember that the most valuable gift you can give is your time—this is a gift to both your classmates and yourself.

Finally, make a **commitment** to complete the reading assignment in the text before class. Reading is very closely associated with deep (real) learning, and is a valuable skill that will enable you to attain true command of the discipline of computer organization and design, and to develop your higher-level cognitive abilities.

**Class Outline and Tentative Schedule**

Although the lectures will somewhat follow the material in the text, we skip certain material and include supplementary topics from other sources. The proposed schedule and sequence below is tentative and may change. We refer to the on-line text, *Computer Organization and Design (1e) – Interactive Version (ARM)* as COD.

**Tentative Schedule by Week**

1. Jan 11,13: Computer architecture: overview, history, and trends; COD Sections 1.1-1.8, 1.10-1.11
2. Jan 18, 20: The instruction; COD Sections 2.1-2.4
3. Jan 25,27: The instruction; COD Sections 2.5-2.8, 2.12, 2.17
4. Feb 1, 3: The processor and performance; COD Sections 4.1-4.3
5. Feb 8, 10: The processor and performance; COD Sections 4.4, Chapter 9 (Appendix C)
6. Feb 15, 17: The processor and performance; COD Sections 4.5-4.8
7. Feb 22, 24: The processor and performance; COD Section 4.9 (introduction and as time allows), Review, and 1st Mini-Exam (covers Weeks 1-4)
8. Mar 1, 3: Review and 2nd Mini-Exam (covers Weeks 5-7); Memory and caching; COD Sections 5.1-5.2
9. Mar 8, 10: Go over exams
10. Mar 22, 24: COD Section 4.9 (cont’d)…March 24 special lecture on Bits as Information
11. Mar 29, 31: Distillation Term Paper assignment; Instruction-level parallelism (ILP); COD Section 4.10; Memory hierarchy; COD Sections 5.1-5.4 (up to ‘Reducing the miss penalty using multilevel caches’ in Section 5.4)
12. Apr 5, 7: Parallel processing; COD Sections 6.1-6.6
13. Apr 12, 14: Accelerators; COD Sections 8.1-8.4 (Appendix B)
14. Apr 19, 21: Security in computer architecture; selecting an MCU; notes, also EE 514 team presentations
15. Apr 26, 28: Writing/Learning (W/L) Week (Instructor feedback on Distillation Term Paper drafts)
16. Week of May 2: Final Exam Week – Distillation Term Papers **due 10:00AM Thursday May 5 (no late papers will be accepted)**

**Course Policies**

**Illness and Attendance:** Please be cautious about attending class if you are feeling ill. Please inform me by email if you are feeling ill **before class**. If you are experiencing flu-like symptoms, you should not attend class; please take precautions not to infect others, and seek medical attention if your symptoms worsen. Absences may also be permitted for other medical reasons or family matters if discussed in advance of the missed class.

**Late Policy:** In general, no late work will be accepted without a documented excuse. If you know that you will miss a deadline, **discuss the matter with me beforehand** to discuss arrangements. Late work will only be accepted for grading if cleared with me in advance or if a documented excuse is presented.

The most important gift you can give to your classmates is your full attention to our discussions and workshopping sessions. Please block all phone calls (except from critical/family numbers) and do not use any social media platform during class sessions.

**Appendix A. UNIVERSITY POLICY STATEMENTS**

# COVID-19 Requirements and Information

**The following statements in red set forth in this document’s first section are specific to NAU’s response to the COVID-19 situation. The requirements outlined below are mandatory until further notice.** They are based upon current public health conditions and guidance and may change as circumstances warrant or new information becomes available. Additional information about the University’s response to COVID-19 is available from the **Jacks are Back!** web page located at [https://nau.edu/jacks-are-back/lumberjack-responsibilities](https://nau.edu/jacks-are-back/lumberjack-responsibilities/).

**FACE COVERING AND PHYSICAL DISTANCING REQUIREMENTS**

Appropriate face masks or other suitable face coverings must be worn by all individuals when present in classrooms, laboratories, studios, and other dedicated educational spaces. To maximize the benefits of physical distancing as an important strategy to help reduce community transmission of the SARS-CoV-2 virus, instructors may implement mandatory student seating arrangements or specific seat assignments. Instructors may remove students who do not cooperate with these requirements from the instructional space in the absence of an approved accommodation arranged through Disability Resources. Failing to comply with these requirements may constitute a violation of the university’s *Disruptive Behavior in an Instructional Setting* policy available at <https://nau.edu/university-policy-library/disruptive-behavior>.

**USE NAUFLEX TO HELP MAINTAIN PHYSICAL DISTANCING**

NAUFlex (available at <https://nau.edu/nauflex/student>) is designed to help all students actively participate in their coursework during the required day and time of a course when they are not physically present in the classroom. This course design model allows students to be fully engaged with faculty and peers and receive the high-quality educational experience for which NAU is known.

**CLASS SESSION RECORDINGS FOR STUDENTS AND FACULTY USE ONLY**

Certain class sessions may be audio or video recorded to help reinforce live instruction during the COVID-19 pandemic. These recordings are for the sole use of the instructor and students enrolled in the course. Recordings will be stored in approved, accessible repositories. By enrolling, students agree to have their image and classroom statements recorded for this purpose, to respect the privacy of their fellow students, and university-owned intellectual property (including, but not limited to, all course materials) by not sharing recordings from their courses. Questions regarding restrictions on the use of classroom audio or video recordings may be addressed to the appropriate academic unit administrator.

# Syllabus Policy Statements

## ACADEMIC INTEGRITY

NAU expects every student to firmly adhere to a strong ethical code of academic integrity in all their scholarly pursuits. The primary attributes of academic integrity are honesty, trustworthiness, fairness, and responsibility. As a student, you are expected to submit original work while giving proper credit to other people’s ideas or contributions. Acting with academic integrity means completing your assignments independently while truthfully acknowledging all sources of information, or collaboration with others when appropriate. When you submit your work, you are implicitly declaring that the work is your own. Academic integrity is expected not only during formal coursework, but in all your relationships or interactions that are connected to the educational enterprise. All forms of academic deceit such as plagiarism, cheating, collusion, falsification or fabrication of results or records, permitting your work to be submitted by another, or inappropriately recycling your own work from one class to

another, constitute academic misconduct that may result in serious disciplinary consequences. All students and faculty members are responsible for reporting suspected instances of academic misconduct. All students are encouraged to complete NAU’s online academic integrity workshop available in the E-Learning Center and should review the full *Academic Integrity* policy available at <https://policy.nau.edu/policy/policy.aspx?num=100601>.

## COURSE TIME COMMITMENT

Pursuant to Arizona Board of Regents guidance (ABOR Policy 2-224, *Academic Credit*), each unit of credit requires a minimum of 45 hours of work by students, including but not limited to, class time, preparation, homework, and studying. For example, for a 3-credit course a student should expect to work at least 8.5 hours each week in a 16-week session and a minimum of 33 hours per week for a 3-credit course in a 4-week session.

## DISRUPTIVE BEHAVIOR

Membership in NAU’s academic community entails a special obligation to maintain class environments that are conductive to learning, whether instruction is taking place in the classroom, a laboratory or clinical setting, during course-related fieldwork, or online. Students have the obligation to engage in the educational process in a manner that does not interfere with normal class activities or violate the rights of others. Instructors have the authority and responsibility to address disruptive behavior that interferes with student learning, which can include the involuntary withdrawal of a student from a course with a grade of “W”. For additional information, see NAU’s *Disruptive Behavior in an Instructional Setting* policy at [<https://nau.edu/university-policy-library/disruptive-behavior>](https://nau.edu/university-policy-library/disruptive-behavior).

## NONDISCRIMINATION AND ANTI-HARASSMENT

NAU prohibits discrimination and harassment based on sex, gender, gender identity, race, color, age, national origin, religion, sexual orientation, disability, or veteran status. Due to potentially unethical consequences, certain consensual amorous or sexual relationships between faculty and students are also prohibited as set forth in the *Consensual Romantic and Sexual Relationships* policy. The Equity and Access Office (EAO) responds to complaints regarding discrimination and harassment that fall under NAU’s *Nondiscrimination and Anti-Harassment* policy. EAO also assists with religious accommodations. For additional information about nondiscrimination or anti-harassment or to file a complaint, contact EAO located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011, or by phone at 928-523-3312 (TTY: 928-523-1006), fax at 928-523-9977, email at [equityandaccess@nau.edu](mailto:equityandaccess@nau.edu), or visit the EAO website at <https://nau.edu/equity-and-access>.

## TITLE IX

Title IX is the primary federal law that prohibits discrimination on the basis of sex or gender in educational programs or activities. Sex discrimination for this purpose includes sexual harassment, sexual assault or relationship violence, and stalking (including cyber-stalking). Title IX requires that universities appoint a “Title IX Coordinator” to monitor the institution’s compliance with this important civil rights law. NAU’s Title IX Coordinator is Elyce C. Morris. The Title IX Coordinator is available to meet with any student to discuss any Title IX issue or concern. You may contact the Title IX Coordinator by phone at 928-523-3515, by fax at 928-523-0640, or by email at [elyce.morris@nau.edu](mailto:elyce.morris@nau.edu). In furtherance of its Title IX obligations, NAU will promptly investigate and equitably resolve all reports of sex or gender-based discrimination, harassment, or sexual misconduct and will eliminate any hostile environment as defined by law. Additional important information about Title IX and related student resources, including how to request immediate help or confidential support following an act of sexual violence, is available at <https://in.nau.edu/title-ix>.

## ACCESSIBILITY

Professional disability specialists are available at Disability Resources to facilitate a range of academic support services and accommodations for students with disabilities. If you have a documented disability, you can request assistance by contacting Disability Resources at 928-523-8773 (voice), 928-523-6906 (TTY), 928-523-8747 (fax), or [dr@nau.edu](mailto:dr@nau.edu) (e-mail). Once eligibility has been determined, students register with Disability Resources every semester to activate their approved accommodations. Although a student may request an accommodation at any time, it is best to initiate the application process at least four weeks before a student wishes to receive an accommodation. Students may begin the accommodation process by submitting a self-identification form online at <https://nau.edu/disability-resources/student-eligibility-process> or by contacting Disability Resources. The Director of Disability Resources, Jamie Axelrod, serves as NAU’s Americans with Disabilities Act Coordinator and Section 504 Compliance Officer. He can be reached at [jamie.axelrod@nau.edu](mailto:jamie.axelrod@nau.edu).

## RESPONSIBLE CONDUCT OF RESEARCH

Students who engage in research at NAU must receive appropriate Responsible Conduct of Research (RCR) training. This instruction is designed to help ensure proper awareness and application of well-established professional norms and ethical principles related to the performance of all scientific research activities. More information regarding RCR training is available at <https://nau.edu/research/compliance/research-integrity>.

## MISCONDUCT IN RESEARCH

As noted, NAU expects every student to firmly adhere to a strong code of academic integrity in all their scholarly pursuits. This includes avoiding fabrication, falsification, or plagiarism when conducting research or reporting research results. Engaging in research misconduct may result in serious disciplinary consequences. Students must also report any suspected or actual instances of research misconduct of which they become aware. Allegations of research misconduct should be reported to your instructor or the University’s Research Integrity Officer, Dr. David Faguy, who can be reached at [david.faguy@nau.edu](mailto:david.faguy@nau.edu) or 928-523-6117. More information about misconduct in research is available at [https://nau.edu/university-policy-library/misconduct-in-research](https://nau.edu/university-policy-library/misconduct-in-research/).

## SENSITIVE COURSE MATERIALS

University education aims to expand student understanding and awareness. Thus, it necessarily involves engagement with a wide range of information, ideas, and creative representations. In their college studies, students can expect to encounter and to critically appraise materials that may differ from and perhaps challenge familiar understandings, ideas, and beliefs. Students are encouraged to discuss these matters with faculty.

*Last revised January 6, 2021*